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Turupadang (2021 :78-83p)

A Mizoroki-Heck Coupling attempt with Pd(OAc)2 as catalyst and amine as base in the absence of Ligand

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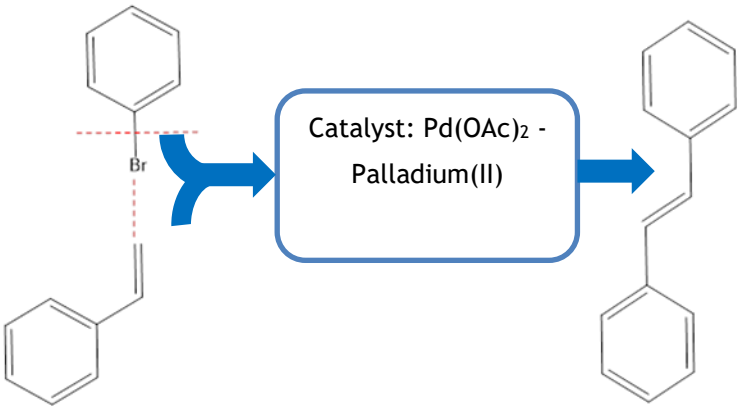

Abstrak

Upaya sintesis bertahap Mizoroki-Heck Coupling (E)-1,2-diphenylethene telah dilakukan dalam suasana inert dari olefin (stirena) dan bromobenzena. Percobaan menggunakan paladium asetat sebagai katalis dan trietilamin sebagai basa serta DMF sebagai pelarut.

Abstract

An attempt to stepwise synthesis Mizoroki-Heck Coupling (E)-1,2-diphenylethene has been done in an inert atmosphere from olefin (styrene) and bromobenzene. The experiment involved palladium acetate as the catalyst and triethylamine as a base along with DMF as solvent.

Keywords: Mizoroki-Heck, catalyst, palladium acetate, olefin, stilbene

Introduction

Palladium complex catalysts are central tools for modern organic synthesis. Palladium complexes are very acquiescent to organic synthesis because reaction conditions can be fine-tuned by varying the ligand, base, solvent, temperature, and additives to optimize the desired process.[1] They have great tolerance of highly diverse functional groups and show excellent stereoselectivity and regioselectivity.[2]

Experiment

The reaction was carried out in a 25mL round bottom flask containing a magnetic stirring bar where a mixture of 0.0045 g palladium acetate (0.02 mmol) in 1 mL DMF of 0.105 mL bromobenzene (1 mmol) of 0.144 mL styrene (1.25 mmol) and 0.139 mL (1 mmol) of triethylamine were placed. A

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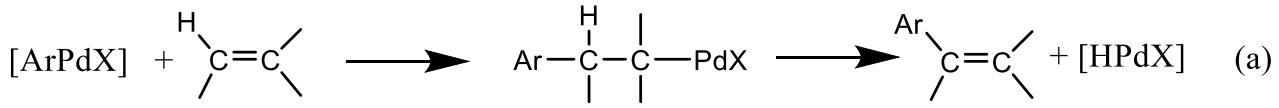
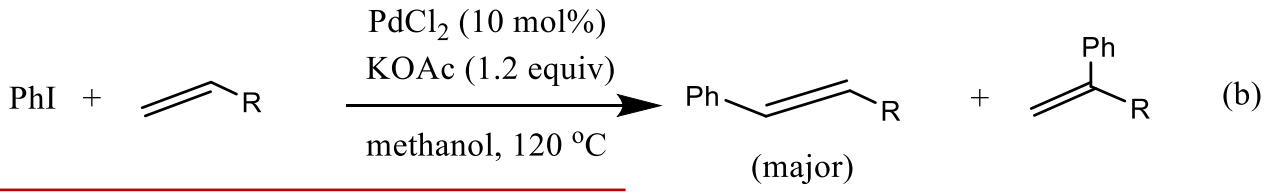
water-cooled condenser was fitted on the flask and heated to around 100°C under nitrogen. The mixture was refluxed and stirring for 16-20 hours. TLC analysis (petroleum ether: ethyl acetate, 1/1, v/v) had been done to check the progress of the reaction at 3hrs, 16hrs, and 20hrs.

Once the reaction has reached completion, the mixture was poured into 10mL of water. The product then extracted by washing the organic layer with 1 M HCl (10 mL), 3 x 10 mL Petroleum ether, 2 x 10 mL brine, dried $MgSO_4$, filtered and concentrated *in vacuo*. The residue was purified on silica gel column chromatography using petroleum ether as the solvent system. The yield was recorded as well as IR and NMR spectra to confirm the structure of the product.

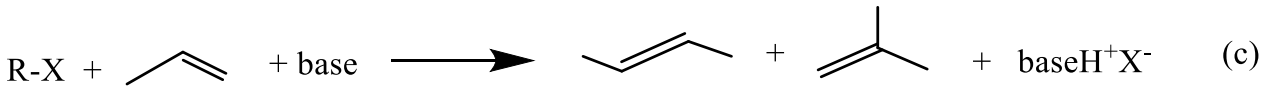
In the late 1960s, Heck reported that arylated alkenes were formed in the reaction of alkenes with a stoichiometric amount of [Ar–Pd-Cl] was generated in situ by reacting ArHgCl with $PdCl_2$ as in Scheme 1a.[3] Then, in n 1971, Mizoroki et al. reported preliminary results on the $PdCl_2$-catalysed arylation of alkenes by iodobenzene in the presence of potassium acetate as in Scheme 1b.[4] Mizoroki-Heck (MH) is the reaction of unsaturated compounds with organic halides as an electrophile as in Scheme 1c. The palladium-catalyzed MH reaction is the most efficient route for the vinylation of aryl/vinyl halides or triflates.[5] C-C bond formation proceeds in the presence of a base.



X= Cl, OAc



R= H, Me, Ph, CO_2Me



R= aryl, vinyl
X= I, Br, Cl, OTf

Scheme 1

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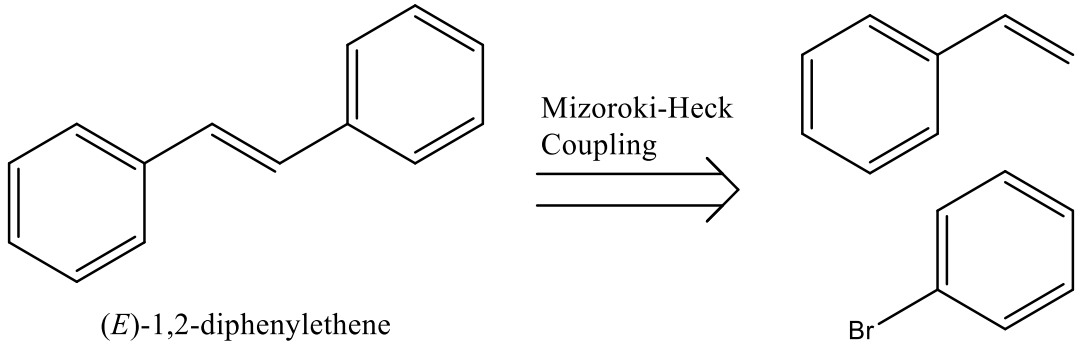

(*E*)-1,2-diphenylethene

Scheme 2

This experiment coupled styrene and bromobenzene in the presence of Pd_2OAc as catalyst without presence of ligand (scheme 2). The first step of the catalytic cycle is an oxidative addition of the aryl bromide to a Pd(0) complex (scheme 3), and resulted in carbon-bromine bond. However, as there was no ligand involved, $Pd(OAc)_2$ must be reduced in situ to a Pd(0) species which initiates the catalytic cycle by an oxidative addition to the aryl bromide (bromide chelate to Pd center)[6]. The next step is the it undergone *syn* insertion of olefin (styrene). This step is also referred to as carbopalladation (formation of a Pd-C bond.[5]

An internal C-C bond rotation in the σ-alkyl–palladium(II) halide brought an sp^3-bonded β-hydrogen in a *syn* position relative to the palladium atom. A syn β-hydride elimination gave a hydridopalladium(II) halide ligated to the arylated alkene. However, when amine (Et_3N) was used, it acted as reducing agents. Indeed, the β-hydride elimination may take place in the amine coordinated to the Pd(II) center, leading to HPdOAc and then to Pd(0) in the presence of the amine.

After dissociation from the arylated alkene, the hydridopalladium(II) halide undergone a reversible reductive elimination to regenerate the active Pd(0) complex. The base shifts this equilibrium towards the Pd(0) catalyst by quenched the hydrogen bromide.

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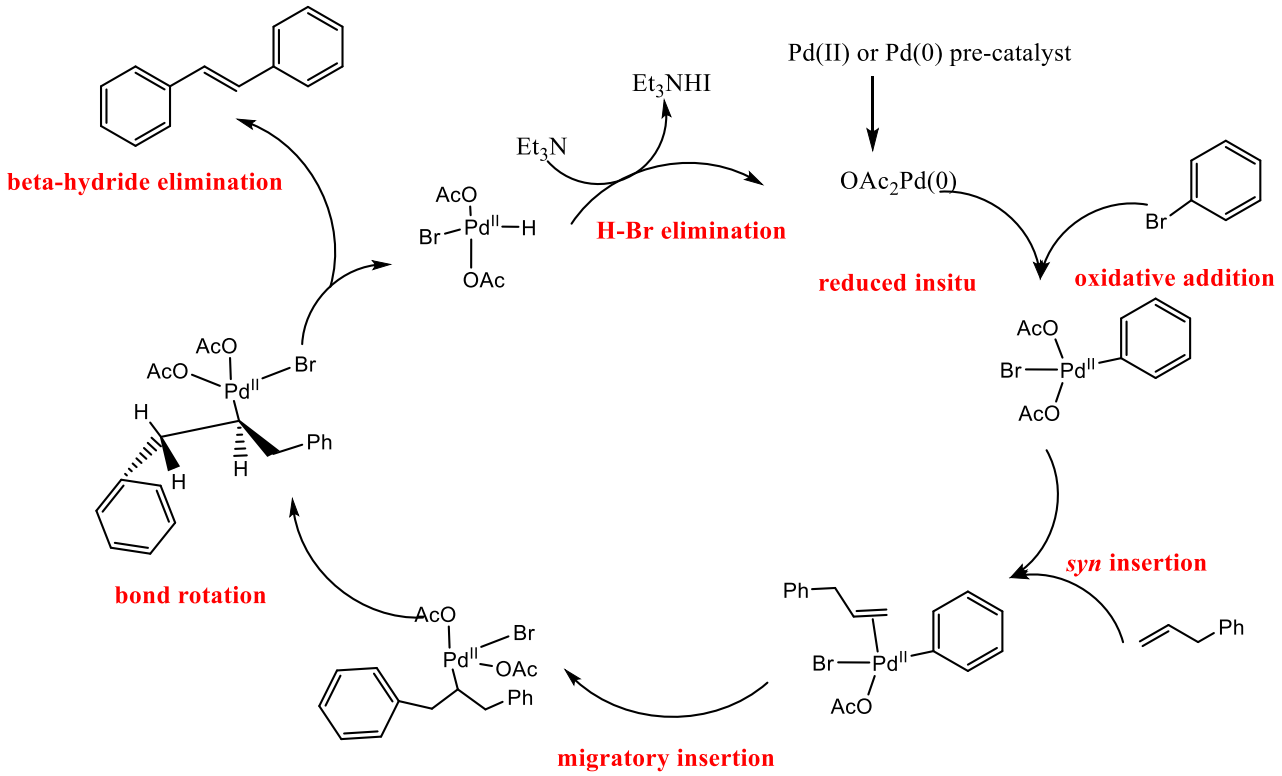

Scheme 3

After 3hrs of reaction, TLC plate indicated that some product has already produced (R_f = 0.45) although it was more confident the reaction has finished after 20hrs (Fig. 1, Supporting materials). Also, the Infrared spectrum showed availability of C-H stretch (2953.97-2851.68 cm^{-1} and 711-735.81 cm^{-1}) and no indication of bromoalkene presence. However, the proton NMR showed that it lacked two protons (appeared as singlet) at the bridge of stilbene. Furthermore, the product showed comparable result to starting material bromobenzene.

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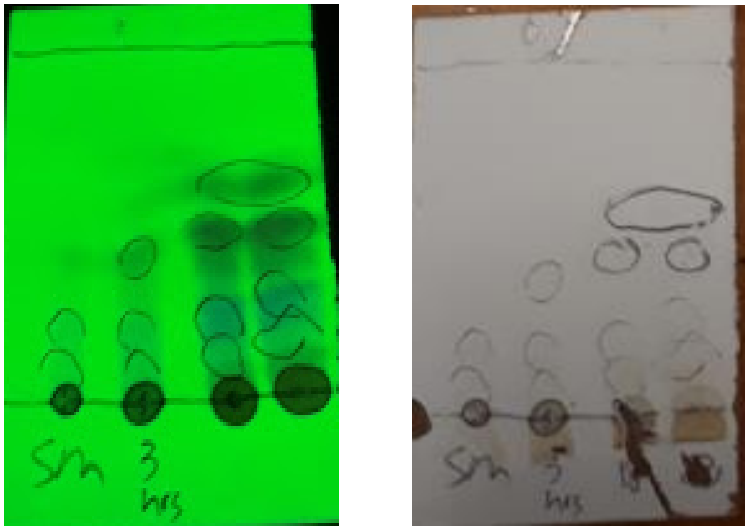
Table 1. Comparison of H^1 NMR stilbene and bromobenzene spectra

Product (stilbene)	Mojtaba Amini et. al. (2012)[6] (stilbene)	Bromobenzene
7.61 ppm (d, J= 7.1 Hz, 1H)	7.60 ppm (d, J=1.0 Hz, 4H)	7.47 ppm (d, J=7.2 Hz, 2H)
7.46 ppm (t, J=7.2 Hz, 1H)	7.43 ppm (t, J=7.5 Hz, 4H)	7.27 ppm (t, 1H)
7.36 ppm (t, J=7.3 Hz, 2H)	7.32 ppm (t, J=7.2 Hz, 2H)	7.19 ppm (t, 2H)
	7.19 ppm (s, 2H)	



(a) (b)

Figure 1. TLC plate compares Starting materials (SM) and 3hrs, 16hrs, 20 hrs reaction; (a) under UV, (b) charred in acid.

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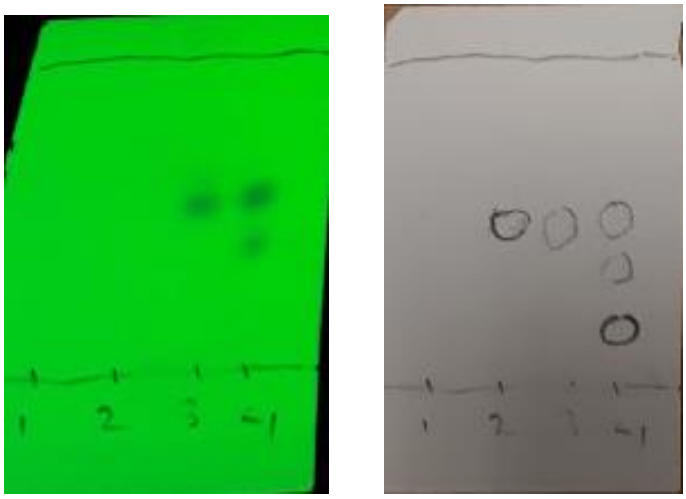

Figure 3. TLC plate result indicated that both fraction 2 and 3 could purified further.

References

[1] a) L. Magna, Y. Chauvin, G. P. Niccolai and J.-M. Basset, *Organometallics* **2003**, *22*, 4418-4425; b) R. K. O'Reilly, V. C. Gibson, A. J. White and D. J. Williams, *Journal of the American Chemical Society* **2003**, *125*, 8450-8451; c) A. Bellomo, J. Zhang, N. Trongsiriwat and P. J. Walsh, *Chemical Science* **2013**, *4*, 849-857.

[2] a) N. Miyaura and A. Suzuki, *Chemical reviews* **1995**, *95*, 2457-2483; b) E. Kıbrıs in *Synthesis of allyl alcohols by paladium-catalyzed 1, 3-substitution reactions of alkenyl epoxides with organoborons, Vol.* İzmir Institute of Technology, **2017**.

[3] R. F. Heck, *Journal of the American Chemical Society* **1968**, *90*, 5518-5526.

[4] T. Mizoroki, K. Mori and A. Ozaki, *J. Org. Chem* **1972**, *37*, 2320.

[5] A. Jutand, *Mechanisms of the Mizoroki–Heck Reaction*, John Wiley & Sons, Ltd.: Chichester, UK, **2009**, p.

[6] M. Amini, M. Bagherzadeh, Z. Moradi-Shoeili and D. M. Boghaei, *RSC Advances* **2012**, *2*, 12091-12095.